

Research Article

# Active restoration of post-mining forest benefits the activity density, but not the diversity of spider communities across the seasons in Ghana

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## Abstract

Forest restoration often involves monitoring programmes to determine whether biodiversity levels and ecosystem services have changed over time. This study investigated changes in ground-hunting spider communities (families Ctenidae, Lycosidae and Zodaridae) in an actively restored forest, an unrestored gravel mine, and two alternative land-use types (agroforestry system and an arable field) to assess whether a two-decade post-mine restoration programme has been successful in restoring biodiversity to levels of a reference natural forest. The overall activity density of ground-hunting spiders (based on both juveniles and adult specimens) was highest in the natural and the restored forest in the dry season and lowest in the arable field and agroforestry system in the wet season. The inverse Simpson index was highest at the gravel site in the wet season, followed by natural forest in both seasons and lower values in the restored forest. The community composition of spiders differed significantly between land-use types (open versus forest habitats) and the interaction between land use and season also differed significantly. The species *Pardosa injucunda* and *Trochosa gentilis* dominated the communities in the restored forest, but *Africactenus monitor* dominated the natural forest and *Hogna gratiosa* dominated communities in the gravel site. Surprisingly, active forest restoration promoted the activity density of ground-hunting spiders displaced by mining activities to levels even higher than in the reference natural forest after two decades. However, the community composition of the restored forest was more similar to the agroforestry system than to the natural forest. These results highlight the benefits of restoring former mining sites but also show the trade-offs in terms of restoration goals, as natural forest biodiversity of spiders was not achieved after 20 years.

**Key words:** Agroforestry system, Araneae, biodiversity conservation, community composition, deforestation, mining

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## Introduction

Global deforestation rates continue unabated, with the majority of deforestation occurring in tropical regions that are home to primary forests and rich in biodiversity (Ritchie et al. 2021). According to the Global Forest Resource Assessment, the world has lost approximately 420 million hectares of forest since 1990 (FAO and UNEP 2020). In Ghana, deforestation rates are particularly high, estimated at 3.5 percent of the total forest area per year, equivalent to 315,000 hectares (World Bank 2020). Agricultural land use, logging, mining, and infrastructure development are the main drivers of deforestation, often leading to ecological imbalances with significant biodiversity and societal impacts in Ghana (Dampney et al. 2021; Abugre and Sackey 2022; Asare et al. 2022; Bentsi-Enchill et al. 2022) and worldwide (Hansen et al. 2010; Foord et al. 2020; Fitzgerald et al. 2021; Masolele et al. 2024). Several local and international initiatives have been introduced to address forest loss in Ghana including reforestation and sustainable land management practices, which aim to reduce forest degradation while restoring degraded ecosystems to support biodiversity and society (Dampney et al. 2021; Kumi et al. 2024). Both passive (unassisted) and active restoration programmes, such as planting tree seedlings, focus on restoring biodiversity while also providing ecosystem goods and services to local human communities (Dampney et al. 2020). Effective monitoring of restoration programmes is an important tool for evaluating outcomes and adjusting or revising restoration strategies, to achieve long-term conservation goals (Hansen et al. 2010; Bullock et al. 2011).

Historically, restoration monitoring in Ghana has often focused on the use of a few indicators such as tree species composition and diversity (Nero 2021) or soil attributes (Dampney et al. 2020; Brown et al. 2024), with little focus on arthropod biodiversity and their important contributions to ecosystem functioning (Birkhofer et al. 2024; Cardoso et al. 2024). The few studies to date that have included arthropods in their forest restoration monitoring programmes in West Africa have focused on higher taxonomic levels (e.g., order or family classification: Kyeremanten et al. 2020; Dampney et al. 2023). Taxonomic surrogacy addresses time and resource limitations and is often sufficient in ecological research due to comparable habitat requirements of species within families or genera (taxonomic sufficiency: Birkhofer et al. 2012). However, results from such approaches may still suffer from the lack of species-level identification, as species within a higher taxonomic group often have different ecological traits and may therefore respond differently to changes in habitat conditions (Ong and Hamid 2022). For a holistic view of the performance of restored ecosystems in terms of arthropod biodiversity recovery, the use of species levels in ecological monitoring programmes is therefore beneficial.

Here, we focus on spiders (Arachnida, Araneae) and their potential role as indicators of restoration success. Spiders are the dominant predators in terrestrial arthropod food webs (Potapov et al. 2022) and provide essential ecosystem services including provisioning (e.g., providing venom for the pharmaceutical industry), regulating (pest control and invasive species management; Dippenaar-Schoeman et al. 2005), supporting (nutrient cycling), and cultural and spiritual (e.g., providing a sense of place) services (Cardoso et al. 2024).

Changes in spider populations can also indicate shifts in insect populations, which are essential for ecosystem functioning (Marc et al. 1999). Spiders are an important food source for a variety of other organisms, including birds, small mammals and other arthropods, contributing to the overall biodiversity of the ecosystem (Marc et al. 1999). They also serve as bio-indicators for ecological monitoring due to their sensitivity to environmental changes caused, for example, by pollution, habitat modification or climate change (Jocqué et al. 2005; Nyffeler and Birkhofer 2017).

Among spiders, some taxa are known to be restricted to more open habitats such as Lycosidae Sundevall, 1833 (Jocqué and Alderweireldt 2006; Juakaly and Jocqué 2021) while others, such as some Ctenidae Keyserling, 1877 (Steyn et al. 2003; Jocqué et al. 2005; Henrard and Jocqué 2017) and the Zodariidae Thorell, 1881 (Jocqué 1993; Nzigidahera et al. 2011; Dankittipakul et al. 2012), are characteristic of tropical forests. These taxonomic groups are therefore ideal for studying the impact of deforestation and monitoring habitat restoration. We therefore studied ground-hunting spider communities of the families Ctenidae, Lycosidae, and Zodariidae in an unrestored and restored gravel mine site 20 years after restoration to determine the restoration trajectory compared to a reference natural forest and two alternative land uses (arable field and agroforestry system) in the dry and wet seasons. Specifically, we investigated how land use and seasonality affected the activity density and species composition of spider communities. We also analysed whether individual spider species preferred certain land-use types or showed a strong seasonality, which might indicate their suitability as indicator species for restoration stages and success.

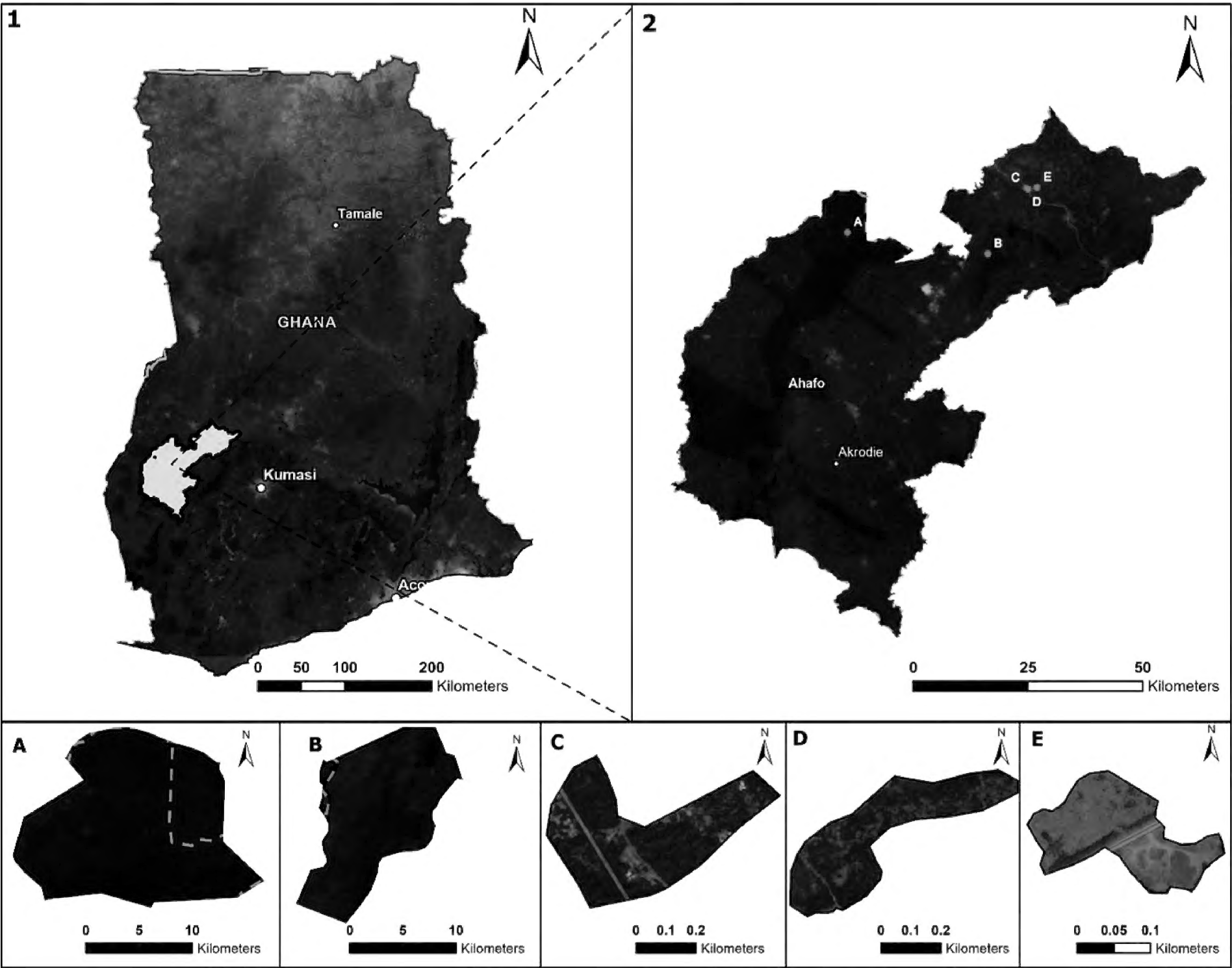
## Methodology

### Study site

The study was conducted in Ghana in the Ahafo region (Fig. 1), which is characterised by semi-deciduous forest (SDFZ), an average annual rainfall between 900 and 1,500 mm, and an average daily temperature of 25 °C. This region is characterised by two distinct seasons: the hot dry harmattan (November to March) and the rainy season (April to October) (Dampney et al. 2020). The Bosomkese Forest Reserve (agroforestry system; AS) is located in the semi-deciduous south eastern forest zone and is situated at 7°6.338'N, 2°14.782'W. The Asukese Forest Reserve (primary natural forest; NF) is located in the humid semi-deciduous north western forest zone at 7°8.469'N, 2°31.107'W.

The Terchire Restoration Area (restored forest; RF), which covers an area of 15.4 ha (2°10.842'N, 7°14.075'W), was exploited for gravel for road construction until 1998 and was actively restored in 1999 by planting indigenous and fast-growing exotic nitrogen-fixing tree seedlings (Dampney et al. 2020). The gravel site (GS) covers an area of approximately 4 ha and is located 1.8 km (7°14.150'N, 2°9.602'W) from the RF (Fig. 1). The GS has been abandoned since 1995 and is colonised by a few shrubby plants (*Chromolaena odorata* and *Pennisetum purpureum*). The arable field (AF) is located around the RF and is cultivated with maize, plantain, cassava and cocoa, among others (Dampney et al. 2020).





**Figure 1.** Map of Ghana (1) showing the Ahafo Region (2) and the studied land-use types (**A** Asukese Forest Reserve - Natural Forest - NF **B** Bosomkese Forest Reserve – Agroforestry System - AS **C** Restored Forest - RF **D** Arable Field -AF **E** Gravel Site-GS).

**Sampling design**

The five land-use types were studied in both seasons (dry and wet) using eight replicated 20 × 20 m plots, resulting in 40 study plots across the five land uses. Ground spider communities were sampled continuously, with five pitfall traps on each plot emptied weekly for 10 weeks in each sampling season. The first sampling campaign was conducted in the dry season (January to March 2019), followed by a rainy season campaign (June to August 2019). Pitfall traps were filled with a 50:50 mixture of ethylene glycol and water, and all pitfall traps were covered with small roofs to prevent the dilution of the trapping fluid by rain (Underwood and Quinn 2010). Pitfall trap samples were stored in 70% ethanol and later sorted into taxonomic groups (order, suborder or family) according to available identification keys for spiders (Dippenaar-Schoeman and Jocqué 1997).

**Sample identification**

In West Africa, most spider species have yet to be described, making it difficult to identify adults to species level due to the lack of taxonomic keys. To overcome this obstacle, the limited literature available (Roewer 1959; Henrard and

Jocqué 2017) was used to place some adults in the correct morphospecies. For others with insufficient or unavailable literature, further species identification was achieved through museum visits to the Royal Museum for Central Africa (RMCA), Tervuren, Belgium, and the Naturmuseum Senkenberg (SMF), Frankfurt, Germany. During these visits, complete identification of adult Ctenidae specimens to species level was achieved and many juveniles could be assigned to a specific genus. Most of the Lycosidae were identified as species by first examining the original taxonomic literature, followed by the examination of the original type specimens at the SMF (Roewer 1959). Only one species of Zodariidae could be identified to species level. The remaining six species (Appendix 2) were given provisional morphospecies codes as they represent undescribed species.

### Data analysis

The overall activity density of spiders was based on the total catch of both juvenile and adult spiders in the families Ctenidae, Lycosidae and Zodariidae. The multivariate species composition of ground-hunting spider community focused only on the composition of identified species in these three families. The multivariate species composition of spider communities in different land uses and seasons, as well as the interaction term between land use and the season, was analysed using permutational multivariate analysis of variance (PERMANOVA) based on  $\log(x+1)$  transformed activity densities of all species from the selected families and Bray-Curtis similarities (Clarke et al. 2014) and an unrestricted permutation of the raw data with 9999 permutations was applied (Anderson 2008). Land-use types (5 levels) and seasons (2 levels) were both used as fixed factors, and plots (8 levels) nested within the land-use types were used as random factors to reflect the repeated measures design. In case of statistically significant differences for a fixed factor, pairwise post-hoc tests were carried out for pairs of levels of factors and were performed using PERMANOVA. The same model was used to analyse the  $\log(x+1)$  transformed overall activity density (the total number of ground-hunting spiders) and the inverse Simpson index based on Euclidean distances in each land use and for the three families. Non-metric multidimensional scaling (NMDS) ordination based on Bray-Curtis similarities was used to indicate the similarity between samples within and between plots of different land-use types and the goodness of fit of NMDS ordinations was assessed based on the 2-D stress value (Clarke et al. 2014). A similarity percentage analysis (SIMPER) was used to identify characteristic species for each land use and season, based Bray-Curtis similarities and a 70% cut-off for total contribution (Somerfield and Clarke 2013).

### Results

A total of 1852 individual spiders from five land-use types (natural forest, agroforestry system, restored forest, arable field and gravel sites) and across two seasons (wet and dry) were identified in the three families. A total of 29 species, comprising 804 males, 397 females and 651 juveniles were identified from the following families: Ctenidae (7 species), Lycosidae (12) and Zodariidae (7) (Appendix 1).

Activity density and inverse Simpson index

The overall activity density of spiders differed significantly between land uses and seasons, and the interaction term between land uses and seasons was also significant (Table 1A). The overall activity density was highest in the restored forest followed by the natural forest (Fig. 2A). The overall activity density was higher in the dry season than in the wet season. The overall activity density of spiders was higher in the restored forest in both seasons and in the natural forest in the dry season than in the other land uses. The restored forest had the highest activity density in the dry season and the arable field had the lowest activity density in the wet season.

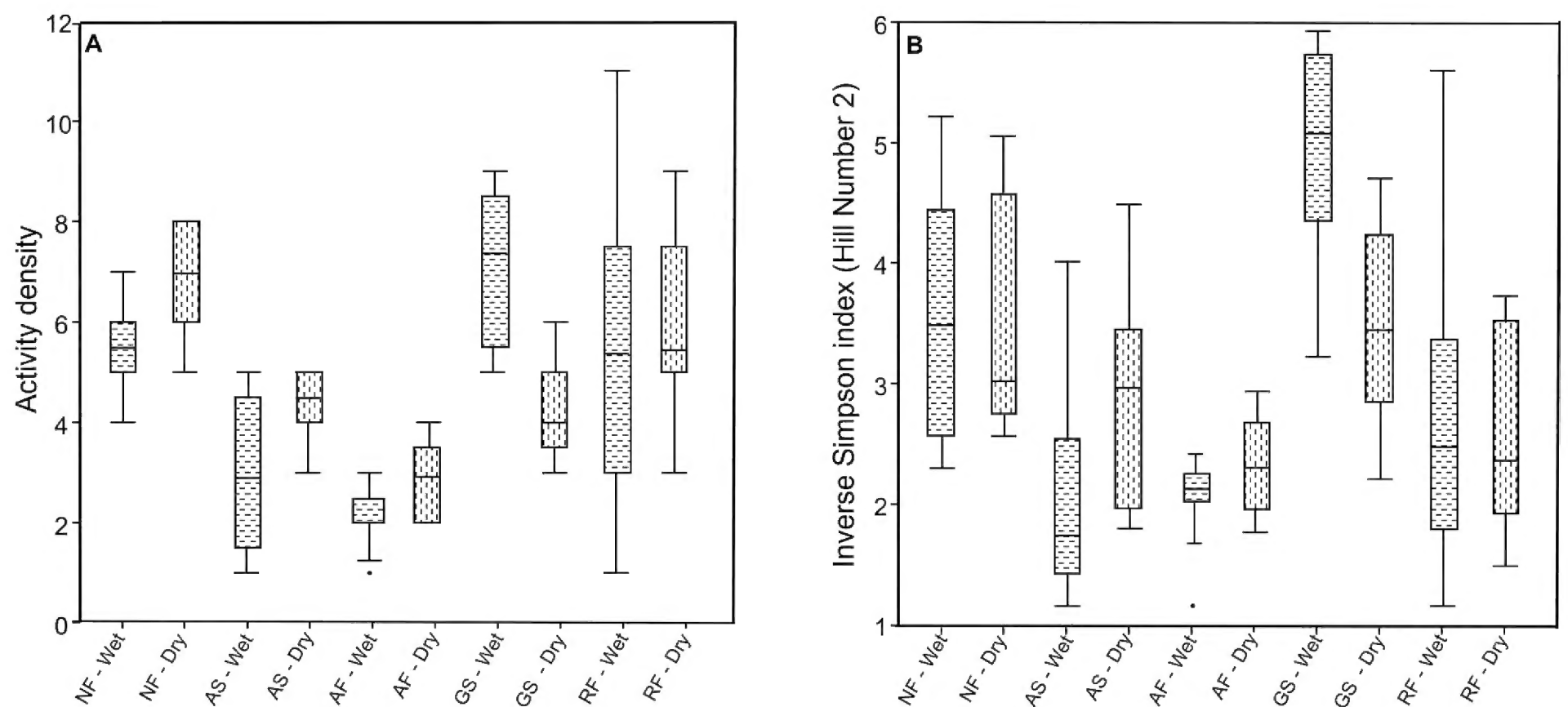
The inverse Simpson index differed significantly between land uses, but not between seasons and the interaction term between land uses and seasons was significant (Table 1B). The inverse Simpson index was highest on the gravel site in the wet season, followed by the gravel site in the dry season and the natural forest in both seasons (Fig. 2B). The inverse Simpson index was lowest in the arable field in both seasons and in the agroforestry system in the wet season.

Species composition across habitats and seasons

The species composition of spider communities differed between land-use types but not between seasons and the interaction term between land uses and season was also significant (Table 1C). The NMDS ordination shows dissimilarities between spider communities in the different land uses and followed a

**Table 1.** PERMANOVA results for the effect of the land use and season on the A) overall activity density, B) inverse Simpson index (Hill number 2) and C) multivariate species composition of spider communities (df: degree of freedom; SS: sum of squares, MS: mean sum of squares, Pseudo-F: F value by permutation, P(perm): P-values based on 9999. Significant effects are in bold.

A) Activity dens.	df	SS	MS	Pseudo-F	P(perm)
Plot	35	4257.90	121.65	1.64	0.072
Land use	4	6057.3	1514.3	12.448	<b>0.001</b>
Season	1	806.45	806.45	10.844	<b>0.002</b>
Land-use x Season	4	907.68	226.92	3.0513	<b>0.031</b>
Res	35	2602.9	74.368		
Total	79	14632			
B) Inv. Simpson	df	SS	MS	Pseudo-F	P(perm)
Plot	35	24.76	0.71	0.66	0.890
Land use	4	47.79	11.95	16.89	<b>0.001</b>
Season	1	0.24	0.24	0.22	0.639
Land-use x Season	4	12.50	3.12	2.91	<b>0.037</b>
Res	35	37.64	1.08		
Total	79	122.91			
C) Species comp.	df	SS	MS	Pseudo-F	P(perm)
Plot	35	50118.00	1431.90	1.35	<b>0.016</b>
Land use	4	78157.00	19539.00	13.65	<b>0.001</b>
Season	1	2235.60	2235.60	2.10	0.059
Land-use x Season	4	8211.40	2052.80	1.93	<b>0.008</b>
Res	35	37175.00	1062.10		
Total	79	175900.00			



**Figure 2.** Overall activity density (**A**) and inverse Simpson index (**B**) (Hill number 2) of spiders for interactions between land-use types (NF, natural forest; AS, agroforestry system; AF, arable field; GS, gravel site; and RF, restored forest) and season (W, wet; D, dry). Single points indicate outliers based on the Median and Interquartile Deviation Method (IQD), the horizontal line is the median, boxes are 25<sup>th</sup> and 75<sup>th</sup> percentiles and whiskers show the 90<sup>th</sup> and 10<sup>th</sup> percentile respectively.

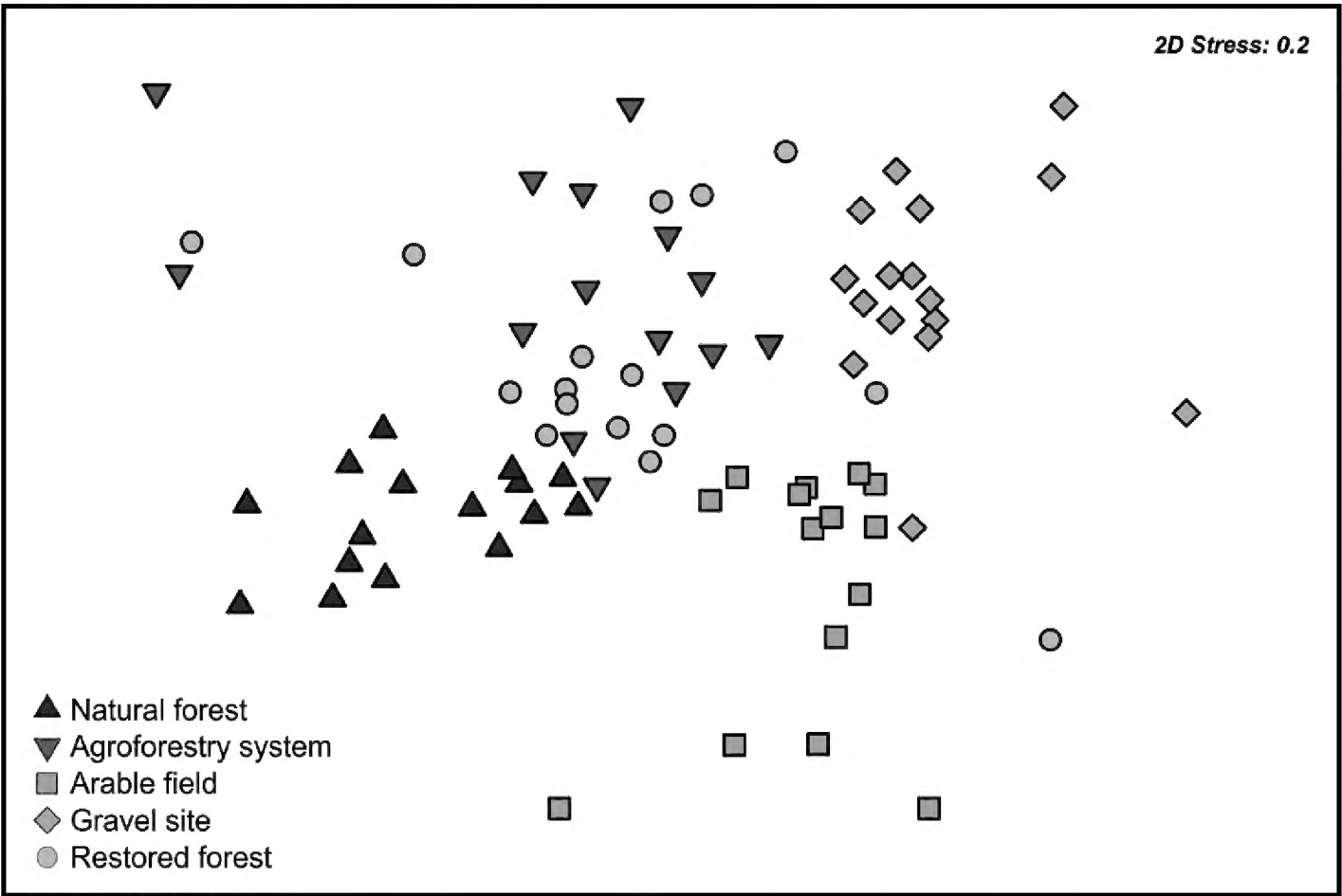
gradient from the gravel site through the arable field, agroforestry system and restored forest to the natural forest (Fig. 3). Spider communities in the agroforestry system overlapped with those in the restored forest.

Communities in the restored forest differed by 64% from the arable field with *Amicactenus eminens* (Arts, 1912), *Africactenus monitor* (Steyn & Jocqué, 2003), *Mallinella* sp3, and *Pardosa injucunda* (O. Pickard-Cambridge, 1876) having higher activity densities in the restored forest and with *Anahita lineata* (Simon, 1897) only present in the restored forest, but absent in the arable field. Furthermore, the communities in the restored forest differed by 68% from the gravel site with *Mallinella* sp3, *P. injucunda* and *Trochosa gentilis* (Roewer, 1960) having higher activity densities in the restored forest (Fig. 4). Similarly, *Hogna duala* (Roewer, 1959), *Hogna gratiosa* (Roewer, 1959), and *Mallinella bandamaensis* (Jézéquel, 1964) had higher activity densities in the gravel site, while *Mallinella* sp3 was only present in the restored forest but not in the gravel site.

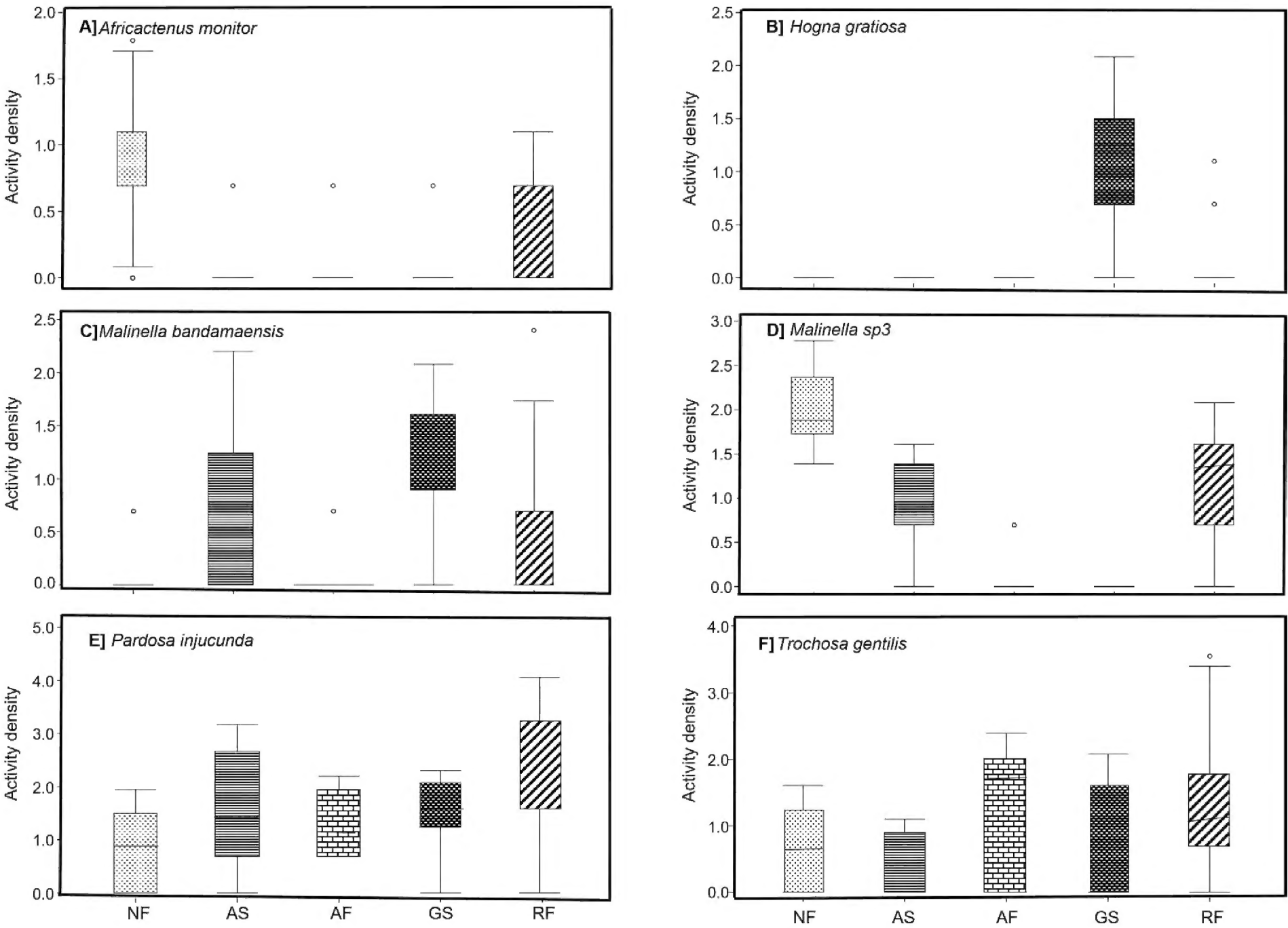
Spider community composition differed by 68% between the restored forest and the gravel site, but the differences were mainly driven by the activity densities of the seven most common species. Higher activity densities of *Mallinella* sp3, *P. injucunda*, and *T. gentilis* were observed in the restored forest than in the gravel site while *M. bandamaensis*, *H. gratiosa*, *H. duala*, and *Hippasosa pilosa* (Alderweireldt, 1996) had higher activity densities at the gravel site. Communities in the reference natural forest differed by 61% from the restored forest with *A. eminens*, *A. monitor*, *Mallinella* sp1, *Mallinella* sp3 and having higher activity densities in the natural forest, and *A. lineata*, present only in the restored but not in the natural forest.

Species composition of spider communities only showed a statistical trend for differences between the wet and dry seasons and with the wet season characterised by higher activity densities of *H. duala*, *H. gratiosa*, *P. injucunda*, and *T. gentilis* (Fig. 5A–D).



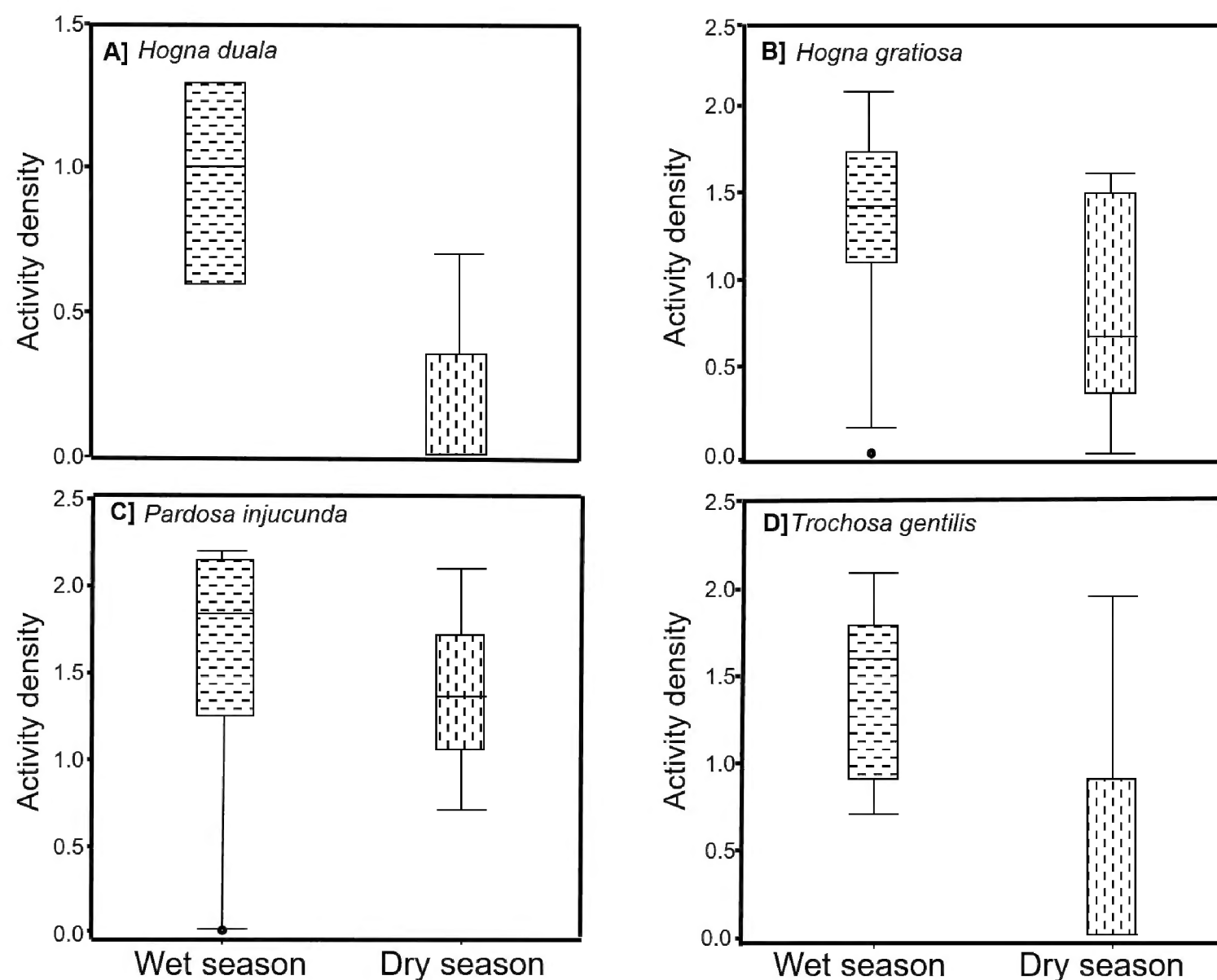


**Figure 3.** Non-metric multidimensional scaling (NMDS) ordination based on log-transformed ( $\log(x+1)$ ) activity densities of spider species and Bray-Curtis similarities between plots of different land-use types. The 2-d stress value is 0.2.



**Figure 4.** Box plots for activity densities of spider species across land-use types: NF, natural forest; AS, agroforestry system; AF, arable field; GS, gravel site; and RF, restored forest. Single points indicate outliers based on the Median and Interquartile Deviation Method (IQD), the horizontal line is the median, boxes are 25<sup>th</sup> and 75<sup>th</sup> percentiles and whiskers show the 90<sup>th</sup> and 10<sup>th</sup> percentile respectively.





**Figure 5.** Box plots for activity densities of spider species across seasons (wet and dry). Single points indicate outliers based on the Median and Interquartile Deviation Method (IQD), the horizontal line is the median, boxes are 25<sup>th</sup> and 75<sup>th</sup> percentiles and whiskers show the 90<sup>th</sup> and 10<sup>th</sup> percentile respectively.

## Discussion

Ground-hunting spider communities in the restored forest reached activity densities similar to the reference natural forest, but the diversity and species composition differed from the natural forest communities and were more similar to communities in the agroforestry system. Several environmental factors such as seasonality, habitat conditions, environmental stability, competition, predation (Ziesche and Roth 2008; Joseph et al. 2018; Juakaly and Jocqué 2021; La Flor et al. 2024) and other anthropogenic factors (e.g., forest encroachment: Foord et al. 2008) may have accounted for these differences in spider communities.

## Activity density and inverse Simpson index

Natural and restored forests had higher activity densities than the unrestored gravel mine and the alternative land uses (arable field and agroforestry system). These forest systems have a more complex structure (Schirmel et al. 2016; Müller et al. 2022), more stable microclimate and environmental conditions (Müller et al. 2022), and higher prey availability (Menéndez-Acuña et al. 2023). The restored forest could be expected to support a more diverse spider community than the natural forest or the open ecosystems (arable fields and gravel mine) due to its dynamic nature in a transitional state. Typically, ecosystems in transition are characterised by unique habitat features (e.g., diverse tree communities, availability of deadwood, deep litter) and their stable environmental conditions (moderate temperature and relative humidity) (Schowalter 2017).

The results of this study are consistent with the findings of previous studies that observed higher spider activity densities as a result of restoration treatments that create complexity in vegetation structures, and provide more ecological niches and resources for spiders (Vymazalová et al. 2021; Dampney et al. 2023).

However, it is surprising to see a high inverse Simpson index of spiders in the gravel site where such habitat conditions are less diverse and low diversity in the restored forest. The inverse Simpson index is sensitive to changes in the most abundant species in a community (Keylock 2005), and a lower value in the restored forest compared to the gravel site indicates the dominance of very few spider species in the restored forest.

The observed differences in activity density between land uses depending on seasons illustrate how seasonal variations affect spider communities in the Afro-tropical region where seasonality is highly pronounced. Seasonal factors such as rainfall and temperature drive habitat conditions and subsequent temporal variation in species assemblages (Campuzano et al. 2020; Zapata et al. 2023). Seasonality is known to influence spider reproduction (e.g., rain favours egg hatching; Quijano-Cuervo et al. 2017), prey availability (e.g., high temperature reduces prey availability; Bidegaray-Batista et al. 2017), and habitat characteristics that influence spider mobility (Weeks and Holtzer 2000). Most spider species have a specific environmental preference, for which their activity is determined by the season that provides a microclimate within their physiological tolerance range (Sudhikumar et al. 2005). The higher activity density of spiders in the dry season than in the wet season could be related to the habitat structure created by the drier conditions, which increases the mobility of spiders and also makes them more susceptible to being captured by pitfall traps (Ahmed et al. 2023). The overall activity density of spiders in this study also considered both adult and juvenile spiders, so the higher activity density in the dry season is mainly due to juvenile spiders.

### Species composition

Spider species composition in forests is largely determined by the diversity of tree species and the vegetation characteristics of habitats, which align with prey densities (Sudhikumar et al. 2005; Spears 2012). In essence, diverse communities provide more resources for spiders to thrive with complex vegetation structures providing additional niches and ecological refugia and protection from predation (Dampney et al. 2023). In a previous study in the same region, Dampney et al. (2023) described the vegetation of the gravel site as homogeneous and less diverse in terms of tree species compared to the heterogeneous and complex habitat structure of the restored and natural forest. It is important to note that only adult species from three families (Ctenidae, Lycosidae and Zodariidae) were considered for our study of community composition, in contrast to the analysis of overall activity density, which focused on both adult and juvenile spiders.

The gradient in community composition observed from the gravel site through the restored to the natural forest highlights the differences in spider communities between the land-use types. The natural forest had a unique spider community, probably driven by its habitat conditions characterised by old forest stands, deadwood and a diverse tree community (Dampney et al. 2023). *Mallinella* sp1, *Mallinella* sp3, and *A. monitor* characterised the natural forest community. *Mallinella* species are a commonly tropical forest-dwelling species

(Jocqué 1993; Dankittipakul et al. 2012) while the species *A. monitor* is a typical forest spider (Steyn et al. 2003; Jocqué et al. 2005; Henrard and Jocqué 2017).

The unique homogeneous habitat characteristic of the gravel site supported specialised species such as *Hogna gratiosa*, and *Mallinella bandamaensis* that are often found in open habitats. *Mallinella bandamaensis*, for example, prefers open degraded habitats and the species is well adapted to hunting prey in such habitats. The unique community of the arable field was dominated by *Pardosa injucunda* and *Trochosa gentilis* as additional species, showing preferences for open and disturbed environments (Liu et al. 2024). *Pardosa injucunda* is known to have high activity densities in open or low vegetation environments such as the arable fields (Liu et al. 2024). Similarly, the low overall activity density of spiders on arable field could be due to the use of pesticides or other agricultural practices such as tillage, which may have reduced spider numbers through direct mortality and indirectly reducing prey availability (Thorbek and Bilde 2004; Benamu 2020).

The restored forest had a spider community with a mix of species from the different land-use types. For example, *Mallinella* sp3, *Pardosa injucunda*, and *Trochosa gentilis*, which characterised the communities in the restored forest, were also observed in the natural forest, agroforestry system and the arable field. This reflects the development stage of the restored forest in terms of biodiversity mimicking spider communities from both the historical stage prior to restoration (gravel site) and the reference land-use types (natural forest).

## Conclusion

Spider communities differed between land-use types depending on seasons, with activity densities, but not diversity or species composition, with the restored forest resembling the natural forest. The species composition of the communities in the restored forest was dissimilar to those in the gravel site and arable field, confirming the intermediate state between these land uses and natural forest. These results highlight the benefits of restoring former mining sites, but also the trade-offs in terms of restoration objectives, as natural forest biodiversity was not achieved after 20 years in restoration approaches that also aimed to provide direct benefits to local human communities (agroforestry system and actively restored forest). Nevertheless, it is clear from our results that restoration strategies are effective at increasing activity densities and certainly more effective from a conservation point of view than leaving degraded systems unmanaged and unable to self-recover.

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## Additional information

### Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

### Ethical statement

The non-invasive sampling methods did not harm or endanger trees and other animals.

### Funding

We declare that no financial support was received from Newmont Gold Ghana Limited.

### Author contributions

Harriet Kinga: Conceptualization, methodology, investigation, taxonomy, data curation, formal analysis, writing. Frederick Gyasi Damphey: Conceptualization, methodology, investigation, formal analysis, writing. Danilo Harms: Conceptualization, taxonomy, formal analysis, writing. Arnaud Henrard: Taxonomy, writing. Rudy Jocqué: Taxonomy, writing. Klaus Birkhofer: Conceptualization, methodology, formal analysis, writing.

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### Data availability

All of the data that support the findings of this study are available in the main text.

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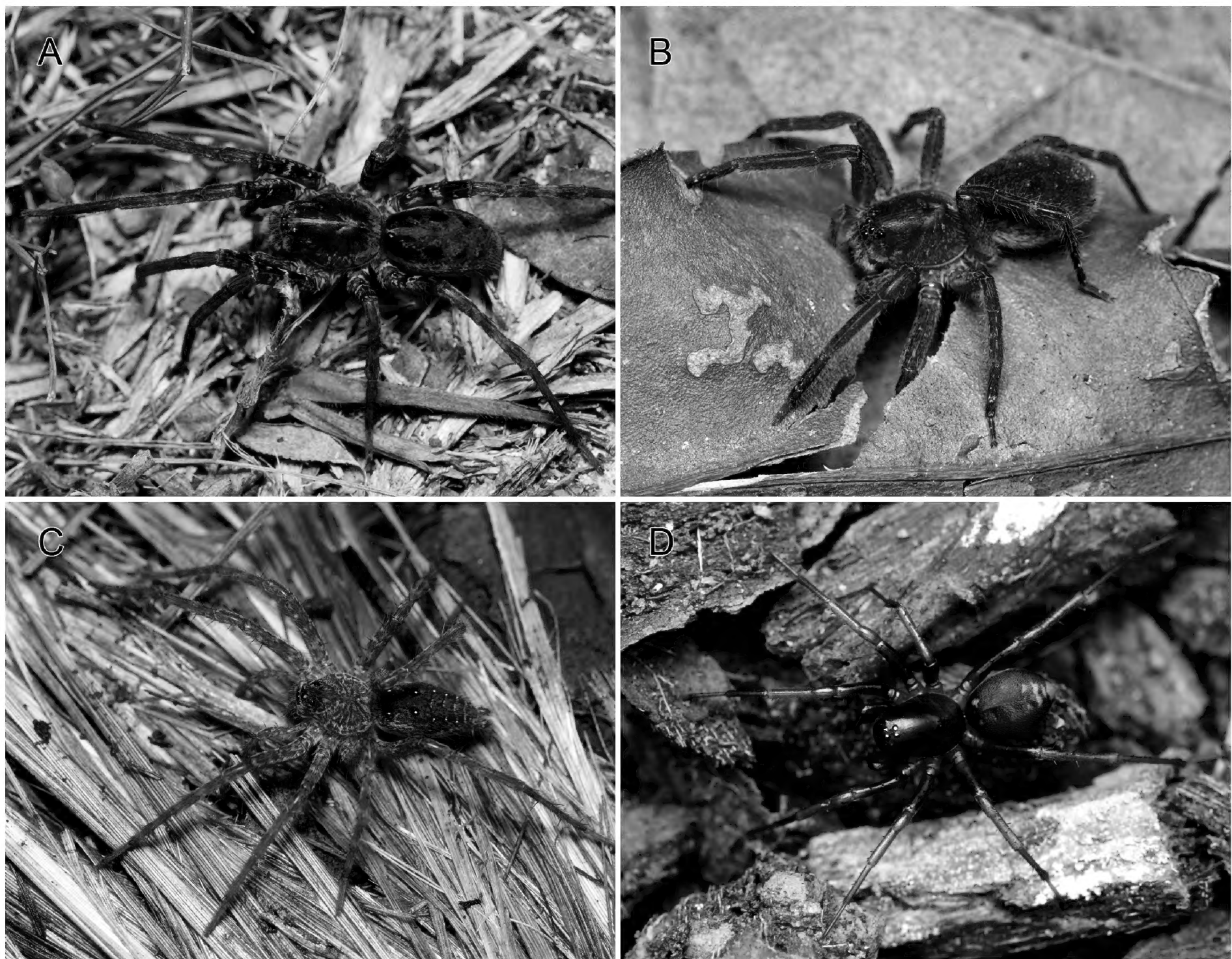


Appendix 1

Table A1. Number of identified spider species on various habitat.

Family	Species	Agroforestry	Arable Field	Gravel Site	Natural Forest	Restored Forest	Total
Ctenidae	<i>Africactenus monitor</i> Steyn & Jocqué, 2003	1	1	1	24	8	35
	<i>Africactenus</i> sp.	1	1		8		10
	<i>Amicactenus eminens</i> Arts, 1912		2		13	9	24
	<i>Amicactenus fallax</i> Steyn & Van der Donckt, 2003				4		4
	<i>Amicactenus</i> sp.	10		2	13	12	37
	<i>Anahita aculeata</i> Simon, 1897			1		2	3
	<i>Anahita lineata</i> Simon, 1897	6		1		16	23
	<i>Anahita</i> sp.	6	2	3	26	15	52
	<i>Petaloctenus bossema</i> Jocqué & Steyn, 1997				3		3
	<i>Petaloctenus</i> sp.	2			12	2	16
	<i>Piloctenus mirificus</i> Arts, 1912				1	1	2
Lycosidae	<i>Alopecosa</i> sp.n		6	1		2	9
	<i>Geolycosa</i> sp.n			1			1
	<i>Hippasa albopunctata</i> Thorell, 1899			5		1	6
	<i>Hippasa lamtoensis</i> Dresco, 1981					1	1
	<i>Hippasa</i> sp.			2			2
	<i>Hippasa brechti</i> Alderweireldt & Jocqué, 2005			4		1	5
	<i>Hippasosa pilosa</i> Roewer, 1960			14	1	2	17
	<i>Hippasosa</i> sp.	1	2	25		6	34
	<i>Hogna duala</i> Roewer, 1959		2	18	1	12	33
	<i>Hogna gratiosa</i> Roewer, 1959			41		4	45
	<i>Hogna simoni</i> Roewer, 1959			2		6	8
	<i>Hogna</i> sp.		4	13	4	5	26
	<i>Pardosa injucunda</i> O. Pickard-Cambridge, 1876	106	56	71	32	253	518
	<i>Pardosa</i> sp.	25	23	48	55	38	189
	<i>Trochosa gentilis</i> Roewer, 1960	11	67	38	22	74	212
	<i>Trochosa mundamea</i> Roewer, 1960			2		3	5
	<i>Trochosa</i> sp.	3	13	27	6	17	66
Zodariidae	<i>Dusmadiores</i> sp.n					1	1
	<i>Mallinella bandamaensis</i> Jézéquel, 1964	27	1	48	3	15	94
	<i>Mallinella</i> sp.	11	2	12	21	18	64
	<i>Mallinella</i> sp1	2	1	1	40	1	45
	<i>Mallinella</i> sp2	2		4	4	2	12
	<i>Mallinella</i> sp3	30	2		148	45	225
	<i>Mallinella</i> sp4				4		4
	<i>Mallinella</i> sp5	8	2	1	5	5	21

Appendix 2



**Figure A1.** Pictures of some spiders observed during the study **A** *Amicactenus eminens* (Arts, 1912), Ctenidae **B** *Piloctenus mirificus* (Arts, 1912) **C** *Hippasa* sp., Lycosidae **D** *Mallinella bandamaensis* (Jézéquel, 1964). Photos by Arnaud Henrard.